

CARNIVOROUS PLANT NEWSLETTER

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Front Cover: *Nepenthes aristolochioides* intermediate pitcher. Article on p68.

Back Cover: *Byblis gigantea* with *Drosera miniata*, near Mt. Lesueur, Western Australia. Article on p81.

Carnivorous Plant Newsletter is dedicated to spreading knowledge and news related to carnivorous plants. Reader contributions are essential for this mission to be successful. Do not hesitate to contact the editors with information about your plants, conservation projects, field trips, or noteworthy events. Contributors should review the "Instructions to Authors" printed in the March issue of each year. Advertisers should contact the editors.

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LETTER FROM THE EDITOR: THE BONN CONFERENCE

Dear fellow carnivorous plant enthusiasts,

The Bonn conference of the ICPS lies behind us now but it is still in very good memory to those who participated in and organized this event, without a doubt the most important one related to carnivorous plants in 1998. I was deeply impressed by not only hearing twenty brilliant lectures by carnivorous plant specialists from thirteen countries (eight speakers having been from outside Europe) but also by witnessing the uniquely friendly and open atmosphere both during and between the sessions. More than 100 attendants from nineteen countries (more than half of them from outside Germany) behaved like a large family rather than like anonymous visitors to a show.

Since it was one of the principal goals of this meeting to bridge the gaps between scientists and amateurs worldwide, it was particularly satisfying for me to hear comments like, "I enjoyed it very much although it was so scientific," or "I would never have thought that it was possible to talk at this familiar level with these great experts whom I have known only from the literature before." I am very grateful to all the people who helped this conference become such a success, in the first line Frank Gallep, president of the German carnivorous plant society (GFP), Prof. Wilhelm Barthlott and Dr. Wolfram Lobin from the Botanical Institute and Botanical Garden of the University of Bonn, the officers of the ICPS, the sponsors who made this event possible financially, the speakers, chairmen, and attendants who made the lectures and discussions such a delightful experience, and Barry Meyers-Rice who co-edited the proceedings of the conference. These proceedings will be made available to ICPS members in due course.

In the international carnivorous plant spirit,

Yours Sincerely
Jan Schlauer

NEWS & VIEWS

Don Schnell (Rt. 1, Box 145C, Pulaski, VA, 24301) sent in a page photocopied from the May 8, 1998 issue of the Statesville Record and Landmark. This article from Associated Press noted that two men were caught at the Baltimore-Washington International Airport with 12000 Venus Flytraps. The two men, one from Hillegom, The Netherlands, and the other from Thurmond, North Carolina, were indicted in the U.S. District Court. Each is charged with conspiracy to sell protected plants, and falsifying plant identification certificates. Another resident of the Netherlands pleaded guilty to attempting to export protected plants when two of his suitcases were found to be filled with Venus Flytraps. He has been treated to a few months in jail.

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SEP 30 1998

REDISCOVERY OF AN OUTSTANDING *NEPENTHES*: *N. ARISTOLOCHIOIDES* (NEPENTHACEAE)

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Received 1 January, 1998

Keywords; observations: *Nepenthes aristolochioides*, *Nepenthes talangensis*

Summary

The morphology and ecology of a recently described *Nepenthes*-species, *Nepenthes aristolochioides* (Jebb & Cheek, 1997) from Central-Sumatra, is described and illustrated in this article.

Introduction

During a visit to the Herbarium of Leiden in 1988 I became aware of a rather poor herbarium specimen of a *Nepenthes* from Central Sumatra marked "new species?" It was collected in 1956 by Prof. Willem Meijer, a well-known *Rafflesia*-specialist. The species seems to be closely related to *Nepenthes talangensis*. In the summer of 1996, Dr. Jan Schlauer organized a meeting with Prof. Meijer in the Palmengarten Frankfurt, Germany. At this meeting, he showed us a photo of the mentioned new *Nepenthes* species with extraordinary new features. The new features of it will be discussed later on in this article. To get more detailed information about it, in June of 1996 Katrin Hinderhofer and I organized a field trip to Sumatra, where we were able to rediscover this species in its natural habitat (see Front Cover). The species has been described recently (Jebb & Cheek 1997) as *Nepenthes aristolochioides*. Because of the new details which we obtained, I will now give a detailed description of the examined material.

Plants usually climbing, climbing stems reaching up to 5-8 m height, the part with adult leaves 3-5 mm thick, cylindrical to obtusely angular, internodes 7-10 cm long, leaves of the rosettes and climbing stems thick, coriaceous, sessile, lanceolate-spathulate, about 8-14 cm long, up to 3 cm broad, apically acute or obtuse, attenuate towards the base, leaves clasping the stem, not decurrent. Pinnate nerves irregularly reticulate, longitudinal ones 3-5 on each side, originating from the leaf base, running parallel in the outer 2/3 of the lamina. Pitchers of the rosettes (Figure 1) originating with a short curve, 3-5 mm wide from the hanging end of the tendril. Tendrils about twice as long as the leaves, without curl. Pitchers utriculate, thick, coriaceous, 5-7 cm high, 2.5-3 cm wide, with two fringed wings, the wings up to 1 mm broad, the fringe segments up to 3-5 mm long, 0.5 to 2 mm apart; mouth orbicular to ovate, up to 1.5 cm wide, oblique to vertical, facing forward. Peristome flattened, 7-20 mm wide, the ribs 1/2 -1/3 mm apart, the teeth of the inner margin 2-3 times as long as broad. Inner side of the pitcher wholly glandular. In the lower half of the pitcher overarched glands, 0.2-0.3 mm in diameter, 200 cm⁻², smaller ones, 500 cm⁻² in the upper part of the pitcher. Lid orbicular to ovate, 1-1.5 cm in diameter, in front of the pitcher. Lower surface without appendage, with rather large glands at the whole surface, especially near the midrib. Three prominent nerves on each side of the midrib. Spur broad and flattened, 3-7 mm long, branched, inserted close to the lid. Pitchers of the climbing stem (Figure 2) originating with a short

curve, 10 mm wide from the hanging end of the tendril, narrow infundibuliform, 7-10 cm high, 2.5-4 cm wide, with 2 prominent ribs; mouth almost to completely vertical, facing forward. Peristome flattened, 4-6 mm wide, the ribs 1/3 mm apart, the teeth of the inner margin 2-3 times as long as broad, not distinct. Interior surface of the pitcher wholly glandular. In the lower part of the pitcher slightly overarched glands, 0.3-0.4 mm in diameter 200 cm⁻², smaller overarched glands in the upper part, 250 cm⁻², 0.2-0.3 mm in diameter. Lid ovate, in front of the pitcher. Lower surface without appendage, with rather large glands over the whole surface. Three to four prominent ribs on each side of the midrib. Spur broad and flattened, 3-5 mm long, branched, inserted close to the lid. Female inflorescence a raceme, the peduncle 4-5 cm long, 2-4 mm thick, the axis 14-15 cm long. The pedicels all of them 1-flowered, the lower ones 12 mm, the upper ones 6 mm long. Fruits 15-20 mm long, the valves lanceolate, 3 to 4 mm broad, gradually attenuate towards both ends. Seeds filiform. Colour of herbarium specimens: Brown to dark brown, pitchers with dark spots. Colour of living specimens: Vegetative parts light green, leaves with white hairs at the margins, pitchers ivory white to reddish with numerous red spots. Rim usually red to dark red, especially in rosette-pitchers. Lid on the lower surface red, on the upper surface yellowish with small red spots.

Distribution and Ecology

This species is only known from a very limited area in central Sumatra, where it grows at an altitude of 2400 m. It grows in mossy forest, climbing in shrubs and small trees. The typical mossy forest with *Sphagnum* on the ground was restricted just to the very top of the explored ridge. Just here some few single plants of *Nepenthes aristolochioides* were found, mostly climbing—only very few rosette-plants were growing in the moss. A gracile type of *Nepenthes singalana* is growing together with *Nepenthes aristolochioides*, usually in *Sphagnum*, sometimes climbing up into the shrubs and treelets.

Other *Nepenthes* Species of This Mountain:

At an altitude of about 1800-2100 m in montane forests and in *Pandanus*-swamps on the shoreline of a crater lake, *Nepenthes gymnamphora* can be found regularly, but scattered. Here, plants climb among shrubs and in the forest. Sometimes the funnel shaped, small upper pitchers can be found.

Nepenthes singalana grows in the same habitat as *Nepenthes aristolochioides*, but in a different ecological niche, as mentioned above. The type of *Nepenthes singalana* growing here is usually quite small and gracile, but also single large ground-pitchers have been found. The upper pitchers are very slender and small, while several (but not all) ground pitchers show very distinct ribs and teeth. *Nepenthes singalana* is also restricted to the mossy forest, but single plants can also be found at somewhat lower altitudes at open places. It is obvious that *Nepenthes aristolochioides* mainly produces pitchers high up in the trees while *Nepenthes singalana* usually bears pitchers at the ground on *Sphagnum* moss, so they colonize different ecological niches in the same habitat. One hybrid between *Nepenthes aristolochioides* and *Nepenthes singalana* has been found growing in *Sphagnum* moss. The mouth of it was nearly vertical.

Trap Mechanism of *Nepenthes aristolochioides*:

The outstanding characteristic of the upper pitchers of *Nepenthes aristolochioides* is the vertical position of the mouth; in this distinctiveness it is unique within the genus *Nepenthes*. This phenomenon can be found in *Nepenthes klossii*



Figure 1: *Nepenthes aristolochioides* ground pitcher viewed from above.



Figure 2: *Nepenthes aristolochioides* upper pitcher.

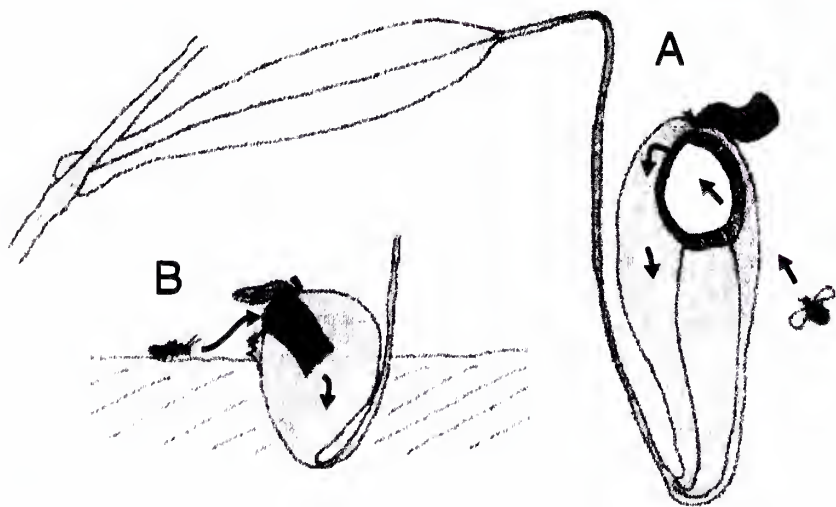


Figure 3: *Nepenthes aristolochioides*. A) proposed trapping mechanism of upper pitcher
B) proposed trapping mechanism of lower pitcher

from Irian Jaya, but not as extreme as in *Nepenthes aristolochioides*. It seems that it is an adaptation to a special ecological niche in this species; the species are not closely related to each other. In the pitchers of the climbing stem of *Nepenthes aristolochioides* it is remarkable that the rim and the lower surface of the lid is usually coloured dark red, but the colour of pitchers is ivory white with red dots. The author presumes that the trap-mechanism of the upper pitchers of *Nepenthes aristolochioides* is like the mechanism in *Darlingtonia californica* or *Sarracenia psittacina* (Sarraceniaceae): the front of the mouth is darkened by the dark red lid and the dark red rim, but small insects are attracted by the light which shines through the ivory white pitchers. Insects get through the dark mouth to the shiny inner side of the pitcher, where they do not find the way back because of the dark entrance; later on the insects become exhausted and fall into the fluid at the ground of the pitcher (Figure 3a). The shiny inner side of the pitcher and the dark mouth can well be observed at Figure 1. In the field, just few small flying insects have been found in the upper pitchers. The mechanism of the rosette-pitchers seems to be quite different; it is striking that the utriculate pitchers bear just an extremely small, nearly vertical mouth with an extremely broad rim to the inner side of the pitcher. It may be something like a wicker trap which catches small crawling insects at the ground. The inner side of the pitcher can easily be reached by crawling insects by crawling through the tunnel of the mouth, but once fallen into the pitcher it is impossible to climb back through the mouth (Figure 3b). More detailed field-observations and analysis of the captured insects may help to demonstrate the real mechanism of these extraordinary traps.

Table 1		
Because of its unique vertical mouth, <i>Nepenthes aristolochioides</i> is clearly distinguished from all other species of Nepenthaceae. <i>Nepenthes aristolochioides</i> shows close affinities to <i>Nepenthes talangensis</i> , but this species has pitchers with a vertical mouth. Table 1 shows some characteristics which clearly distinguish <i>Nepenthes aristolochioides</i> from <i>Nepenthes talangensis</i> .		
Characteristic	<i>Nepenthes aristolochioides</i>	<i>Nepenthes talangensis</i>
mouth of upper pitchers:	vertical	horizontal
mouth of lower pitchers:	oblique to vertical	horizontal
shape of mouth:	oblique to ovate, without neck	elevated into a short neck
insertion of lid:	in front of the pitcher	above the pitcher
size of mouth in lower pitchers:	1-1.5 cm wide	3-5 cm wide
size of lid in lower pitchers:	1-1.5 cm in diameter	3-4 cm in diameter
orientation of rim of lower pitchers:	elongated towards the inner side of the pitcher	around the horizontal mouth
growing habit:	usually climbing high up into the trees or high shrubs; with long internodes	usually growing as rosettes or climbing in low shrubs

Conservation

Nepenthes aristolochioides seems to be an extremely endangered species because of its very small range, which is just known from two mountains in Central Sumatra! At moment, the habitats are not endangered by logging because both are situated in Nature Reserves, but too enthusiastic collectors could endanger the known population dramatically. So it remains the responsibility of all of us not to disturb such fragile populations of Nepenthaceae. Owing to the horticultural interest in this species, the precise locality is omitted from this description.

Acknowledgments

I would like to thank Dr. Jan Schlauer for critical reading of this paper and Matthias Schmidt for preparing the illustrations. I want to thank Heiko Rischer and Dr. Andreas Wistuba for helpful general discussions. I would like to thank Mr. Andy Adek from Sumatra for his valuable help through many years in the organization and realization of most of our field-trips in Sumatra-Barat. I want to thank the staff and directors of Rijksherbarium Leiden and Royal Botanic Gardens Kew for the possibility to study the material of Nepenthaceae. Last but not least I want to thank Katrin Hinderhofer, who accompanied me to this field-trip.

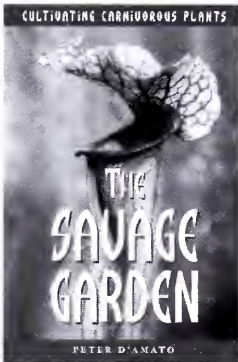
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BOOK REVIEW

D'Amato, Peter. 1998. The Savage Garden: Cultivating Carnivorous Plants. Ten Speed Press, Berkeley, CA, USA. ISBN 0-89815-915-6, 314 p. + xxii, approximately 230 photographs and illustrations, most in color. A quality paperback, 15 × 23 cm (6 × 9 in), \$19.95.

Reviewed by Barry Meyers-Rice



There are already several full-sized books on growing carnivorous plants. Granted, Slack's works are very hard to find, but Cheers wrote a fine volume. Do we really need another? In answer, I tell you to run, not walk, to the nearest bookseller and buy D'Amato's new book, *The Savage Garden*.

First, the basics. The book is only available as a paperback, and the signatures appear to be glued and not sewn. However, the paper has a high clay content and even after being soaked with greenhouse water it dries well. The book's layout is clear and efficient—every part of every page is filled with crisply printed illustrations or text. The photographs are not as large, numerous, or stunning as those in Cheers,

but instead serve a supporting role of illustrating the text. (Although some are heart-stoppers, such as the astonishing image of *Nepenthes hamata* that makes *N. bicalcarata* look as alarming as a bean sprout.)

Cultivation is the focus of the book. For example, D'Amato dedicates nearly an entire page to color photographs of planting media used in carnivorous plant horticulture! Then, following nearly fifty pages on basic cultivation, D'Amato offers 230 more on detailed guidelines for each genus. The monotypic genera such as *Darlingtonia*, *Cephalotus*, and *Drosophyllum* are covered in just a few pages each, while the sections on the big genera are more expansive. D'Amato outdoes himself with a sundew chapter nearly fifty pages long! At no point did I disagree substantially with his cultivation prescriptions—with thirty years of experience, he knows his subject matter. When weighing his advice, it is good to remember that D'Amato

grows plants in north-coastal California, while Adrian Slack was based in a much different climate in England. Accordingly, differing cultivation methods are recommended by the two authors for various plants. (For example, D'Amato ignores entirely Adrian's method of growing *Drosophyllum* in nested pots, a technique my cronies and I often call "slack-potting"!) The reader should follow the guidance of the author who gives the most sensible advice, considering the reader's home climate.

But perhaps beyond all this, what really sets D'Amato's book apart is his ability to bring across a sense of gothic fun. Plants are shown growing in abalone-shells, gravy-boats, porcelain hearts, swans, and a *U. sandersonii* planter too hideously kitschy to describe. His figure captions are similarly nutty, "Upon entering this doorway, an insect is assured a painful death," "An autopsy on *Sarracenia* proves they are gluttonous pigs," and "The bizarre upper pitchers of *Nepenthes lowii*. Toilet bowls for birds?" If the book were not so completely authoritative on cultivation, these bits of comedy might undermine its credibility. Instead, they reveal the twisted humor of the author.

I am no sycophant—The Savage Garden does have flaws. Some are minor but oddly consistent spelling errors (e.g. "*N. bicalcurata*," "*U. reinformis*," "*U. humboldtii*," "thripes," and others). More significant is D'Amato's confusing use of a flurry of unpublished cultivar names. It is hoped these are mended in future editions.

The Savage Garden is informative, accurate, entertaining, and at \$19.95 it is a bargain. An incident which captures its essence occurred when I was first reading it and started laughing raucously at a photo caption (page 250, guess which). My girlfriend came in from another room, "Let me guess, Peter D'Amato's book again?" The Savage Garden reminds me—a hardened old soul—of the magic of carnivorous plants and why I love them.

LITERATURE REVIEWS

Barthlott, W., Porembski, S., Fischer, E., and Gemmel, B. 1998, First Protozoa-Trapping Plant Found, *Nature*, 392, 447.

The carnivorous natures of *Genlisea aurea*, *G. margaretae*, and *G. violacea* were investigated. By placing ciliate protozoa such as *Blepharisma americana* in a Petri dish with *Genlisea* traps, it was found that protozoa were attracted to and then captured by the traps. Meanwhile, the protozoa were not attracted to roots of *Eriocaulon plumale* (a different wetland plant). It is not described how the investigators parameterised the clustering of protozoa around the *Genlisea* traps, so it is unclear how significant these results are. Furthermore, while protozoa were subsequently found inside the *Genlisea* traps, no statistical estimates are presented of the likelihood that their occurrences in the traps were the results of random exploration by the protozoa. Since the attractive properties of the traps to other possible prey are not discussed, it is hard to justify the authors' claims that *Genlisea* is a "highly specialized protozoan trap." However, their results are evocative, especially since their field studies of *G. stapfii* traps revealed the presence of numerous trapped protozoans (and, presumably, no other prey types). When ciliates marked with the isotope ³⁵S were trapped by *Genlisea*, the isotope was traceable in rosette leaves, verifying the carnivorous nature of these plants. These are exciting findings and it is hoped that further, more compelling results are published by the authors. (BAMR)

Dress, W.D., Newell, S.J., Nastase, A.J. and Ford, J.C. 1997, Analysis of Amino Acids in Nectar from Pitchers of *Sarracenia purpurea* (Sarraceniaceae), *Am. J. Bot.*, vol. 84, 1701-1706.

The amino acid composition of nectars from the extrafloral nectaries (nectar glands that are not part of flowers) of the pitchers of *Sarracenia purpurea* were analyzed. These nectaries act as lures for prey insects. The amino acids varied so that no single amino acid was found in all thirty-two pitchers examined. Nine amino acids (methionine, valine, cysteine, serine, aspartic acid, glycine, histidine, glutamic acid, hydroxyproline—in order of decreasing abundance) were present in at least twenty of the samples. No other amino acid occurred in more than twelve samples. The possibly significant cost of amino acid secretion is discussed by the authors in terms of being offset by increasing the plant's attractive properties, and therefore also capture of prey insects (a quite obvious phenomenon of nectaries in general). (JS)

Gallie, D.R., and Chang, S.C. 1997, Signal Transduction in the Carnivorous Plant *Sarracenia purpurea*, *Plant Physiol.* 115, pp. 1461-1471.

This paper on the physiology of *Sarracenia purpurea*, only apparently a well-studied plant, is somewhat unusual among recent publications on this topic by the predominantly experimental (rather than conjectural or traditional) nature of the facts the discussion is based upon. And quite expectedly, very interesting and important new observations are communicated in this article. It is shown by enzymological investigations that proteolytic and other hydrolytic (nuclease, ribonuclease, and phosphatase) activities are secreted by the plant autonomously within the first days after pitcher opening (irrespective of the water content of the pitcher). Later on, these activities decrease in the absence of external stimuli, but the secretion of the enzymes is triggered as soon as chemical stimulants like protein, nucleic acids, or ammonium chloride are added to the pitcher fluid. Microbial contamination is demonstrated not to play any role previous to the second week after pitcher opening, but the secretory behaviour of the plant is essentially independent from microbial action even after months.

Sarracenia purpurea subsp. *purpurea*, the plant the experiments have been performed with, is misspelt *S. purpurea* spp. (meaning species, plural) *purpurea* (i.e., p.1462), but this does not cause ambiguity.

This excellent paper, which is not only remarkable for the clearly designed experiments but also by the carefully performed controls, demonstrates for the first time beyond any doubt that *Sarracenia purpurea* does secrete endogenous hydrolytic enzymes, so this species (the only one in the genus for which this has been doubted occasionally) is an autonomously digesting, truly carnivorous plant. Moreover, the ability to regulate enzyme secretion depending on stimulants present in the pitcher fluid is apparently a new (albeit not an entirely surprising) characteristic for the genus, minimizing the risks and costs associated with carnivory as a means to maximize the benefits of extracting nutrients from the prey. (JS)

Heubl, G., and Wistuba, A. 1997, A Cytological Study of the Genus *Nepenthes* L. (Nepenthaceae), *Sendtnera* 4, pp. 169-174.

In this paper the genus *Nepenthes* is demonstrated to be cytologically uniform with $2n=80$ chromosomes in all 15 species investigated. These counts confirm the preliminary data communicated by Lowrey (*Am. J. Bot.* 78 (6 Suppl.), pp. 200-201,

1991) and likewise contradict the first counts reported by Kondo (2n=78, Bull. Torr. Bot. Cl. 96, pp. 322-328, 1969). The homogeneity within *Nepenthes* explains why most species hybridize readily. A cytological comparison is made between Nepenthaceae and Droseraceae, several species in the latter having 2n=20 chromosomes, and a few polyploid taxa having as much as 2n=80 chromosomes. In the light of recent data on the composition of the order Nepenthales, which includes the families Polygonaceae, Plumbaginaceae, Nepenthaceae, Droseraceae, Drosophyllaceae, Dioncophyllaceae, Ancistrocladaceae, Frankeniaceae, and Tamaricaceae, the scope should perhaps have been extended also to some of the other families in this order (2n=20 being common e.g. also in *Rumex* and *Polygonum*, Polygonaceae). (JS)

Jebb, M., and Cheek, M. 1997, A Skeletal Revision of *Nepenthes* (Nepenthaceae), Blumea 42, pp. 1-106

This paper is intended as a precursor for the treatment of Nepenthaceae in Flora Malesiana, the standard flora covering most of the distributional range of *Nepenthes*. Six species are described as new. These are: *N. argentii* from the Philippines (featured already in Carniv. Pl. Newslett. 27, pp. 6-11, 1998), *N. aristolochioides*, a remarkable species from Sumatra with small pitchers that have a vertical peristome, *N. danseri* from Waigeo island west of New Guinea, *N. diatas* from north Sumatra that is closely related to *N. singalana*, *N. lamii*, the species from New Guinea that has formerly been united with the New Caledonian *N. vieillardii*, *N. macrophylla* (specific rank for what was originally described as *N. edwardsiana* subsp. *macrophylla*), and *N. murudensis*, a plant known only from Gunung Murud, Sarawak, Borneo, that has a compelling similarity to *N. tentaculata* but larger pitchers (it has been regarded as a hybrid involving *N. tentaculata* previously).

Several taxa are redefined, the Sumatran taxa *N. pectinata*, *N. eustachya*, and *N. sumatrana* are considered distinct from the Javanese *N. gymnamphora*, the Philippine *N. alata*, and the New Guinean *N. treubiana*, respectively. On the Malayan peninsula, *N. ramispina* is split from *N. gracillima*, on Borneo *N. hispida* is split from *N. hirsuta* (with which *N. leptochila* is united). *N. carunculata* is included in *N. bongso*, a decision which is justified if the specimens identified as *N. bongso* by Danser do belong to the taxon described by Korthals originally. In this case, *N. talangensis* cannot be included in *N. bongso* like it is quite surprisingly done in the present paper. *N. fallax* is included in *N. stenophylla*, although a specimen is selected as the lectotype of the latter that does not belong to the same taxon as *N. fallax*, so essentially Danser's misconception is perpetuated. A better solution must be found soon if further confusion should be avoided.

All new species and several of the redefined ones are illustrated by line drawings and described in detailed English descriptions. *N. deaniana*, *N. junghuhnii*, *N. melamphora* var. *lucida*, *N. neglecta*, and *N. smilesii* are treated as little known taxa, *N. cincta*, *N. cristata*, and *N. lindleyana* are excluded.

The paper is a must for all interested seriously in the taxonomy of *Nepenthes*, and it is another important step towards an improvement of Danser's classical treatment. However, several debatable points have to be clarified previous to the completion of the Flora Malesiana account. (JS)

Lowrie, A. 1998, A New Species of *Utricularia* (Lentibulariaceae) from the South-West of Western Australia, Nytsia, vol. 12, 37-41.

A plant reportedly considered a variant of *Utricularia dichotoma* (a widespread

and fairly variable species) by Peter Taylor (Kew Bull. Add. Ser., vol. 14, 108-113, 1989; the specimens described here are, however, not mentioned in this context) is described under the name *U. paulineae* (recte: *paulinae*). The distinguishing features are the lemon yellow (rather than violet) upper corolla lip, spur longer than corolla lower lip (shorter in *U. dichotoma*), and capsule shorter than calyx (longer in *U. d.*). Peter Taylor is mentioned in the acknowledgements, but unfortunately nothing is mentioned about his opinion on the new taxon. (JS)

Lowrie, A. and Conran, J.G. 1998, A Taxonomic Revision of the Genus *Byblis* (Byblidaceae) in Northern Australia, *Nuytsia* 12, 59-74.

Botanist, adventurer, and author Allen Lowrie is well known to readers of Carnivorous Plant Newsletter. In this paper, coauthored by John Conran, he adds three new species to the genus *Byblis*, which previously only contained *B. gigantea* and *B. liniflora*. The three new species are *B. aquatica*, *B. filifolia*, and *B. rorida* (actually, *B. filifolia* is a name resurrected from an 1848 description). The new species are all similar to *B. liniflora*—indeed *B. filifolia* is what was recently named *B. liniflora* subsp. *occidentalis*. The four species, *B. aquatica*, *B. filifolia*, *B. liniflora*, and *B. rorida* can be distinguished from each other by a number of characteristics. These will be discussed in a future article in Carnivorous Plant Newsletter, but diagnostic characters are: 1) *B. liniflora* has anthers shorter than its filaments, seeds 0.8 mm long or smaller, and pedicels as long as or longer than the leaves; 2) *B. aquatica* has anthers shorter than its filaments, seeds 1.0 mm long or longer, and pedicels as long as or shorter than the leaves; 3) *B. rorida* has anthers as long as or longer than its filaments and has glandular hairs 0.7-1.5 mm long on its sepals; 4) *B. filifolia* also has anthers as long as or longer than its filaments but the glandular hairs on the sepals are only 0.3-0.5 mm long. In addition to the name *B. liniflora* subsp. *occidentalis*, *B. filifolia* has been known to horticulturists as *B. aff. liniflora* “Kununurra,” while *B. aquatica* has been known as *B. aff. liniflora* “Darwin.” Range maps are included for all four species. Only time will tell if the division of *B. liniflora* into four species is maintained, but the characteristics outlined in this paper are compelling. (BAMR)

Newell, S.J., and Nastase, A.J. 1998, Efficiency of Insect Capture by *Sarracenia purpurea* (Sarraceniaceae), the Northern Pitcher Plant, *Am. J. Bot.*, vol. 85, 88-91.

By videotaping pitchers, the insect capture efficiency of *Sarracenia purpurea* was found to be low. Ants may deprive the plants of more nutrients (nectar) than they provide as prey. (JS)

Schulze, W.E., Schulze, E.D., Pate, J.S., and Gillison, A.N. 1997, The Nitrogen Supply from Soils and Insects During Growth of the Pitcher Plants *Nepenthes mirabilis*, *Cephalotus follicularis* and *Darlingtonia californica*, *Oecologia*, vol. 112, 464-471.

The distribution of nitrogen derived from sources outside the plant (prey) has been studied in several different pitcher plants by comparisons of the relative abundance of the two stable nitrogen isotopes ^{14}N and ^{15}N that are present in different amounts in different natural sources. The authors confuse the pitcher lid of *Nepenthes* with the leaf tip (on their Fig. 1), although this was shown by Hooker in 1858 to be the dorsal spur at the lid base. Nevertheless, the fundamentally different anatomical nature of the traps of *Nepenthes*, *Darlingtonia*, and *Cephalotus* is

recognized. Comparisons of the characteristic nitrogen isotope ratios of prey, non-carnivorous plants growing at the same sites as the pitcher plants investigated, and different parts of the pitcher plants showed an increase of apparently prey-derived nitrogen in the younger, pitcherless parts of the pitcher plants. This leads the authors to the conclusion that prey derived (nitrogen-rich) nutrients are actively transported towards the young, actively growing (but not yet carnivorous) tissues of the plants. One major logical problem is the fact that in some samples (young parts of *Nepenthes mirabilis*) the nitrogen isotope pattern is shifted farther from the typical plant ratio to the insect side than in the insects themselves, which would necessitate an isotope-selective concentration process in the plant. If such processes were in operation, however, the whole method would be entirely meaningless for the question addressed. (JS)

Zamudio, S. 1997, Redescubrimiento de *Pinguicula clivorum* Standl. et Steyerl. (Lentibulariaceae), Una Especie Rara de Guatemala y Mexico, Acta Bot. Mex., vol. 39, 61-65. (Spanish with English abstract)

In 1944 Standley and Steyermark described *Pinguicula clivorum*, a Mexican species with a markedly zygomorphic flower and a homophyllous rosette of obovate leaves. Casper and others later concluded this plant was probably synonymous with *Pinguicula lilacina* Schltld. et Cham. By studying the herbarium isotype and holotype, Zamudio concludes the specific name *P. clivorum* was justified. Furthermore, the species *P. barbata* Zamudio et Rzedowski is found to be a synonym of *P. clivorum* (the latter name of course having publication precedence). Of the Mexican *Pinguicula* of subgenus *Themnoceras*, *P. clivorum* can be identified by the following: 1)its corolla lobes are entire (eliminating *P. crenatiloba* and *P. emarginata*, which have irregularly incised margins); 2)its rosettes are 3.5-10 cm in diameter, and are homophyllous (*P. immaculata* and *P. gracilis* have tiny 1-2 cm, heterophyllous rosettes). *P. clivorum* is known only from Chiapas (Mexico) and Guatemala. (BAMR)

Zamudio, S. 1997, Una Especie Nueva de *Pinguicula* (Lentibulariaceae) de Centroamerica. Acta Bot. Mex., vol. 40, 65-69. (Spanish with English abstract)

Pinguicula mesophytica is described as a new species. It belongs to sect. *Orcheosanthus* and is very similar to *P. moranensis*, but the smaller corolla lobes are rounded rather than cuneate, the leaves have ciliate petioles, and the plant is epiphytic or rupicolous. These plants from Guatemala, Honduras, and El Salvador have been identified with the Mexican *P. moranensis* in the past. (JS)

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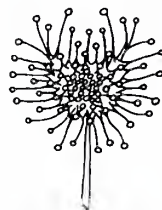
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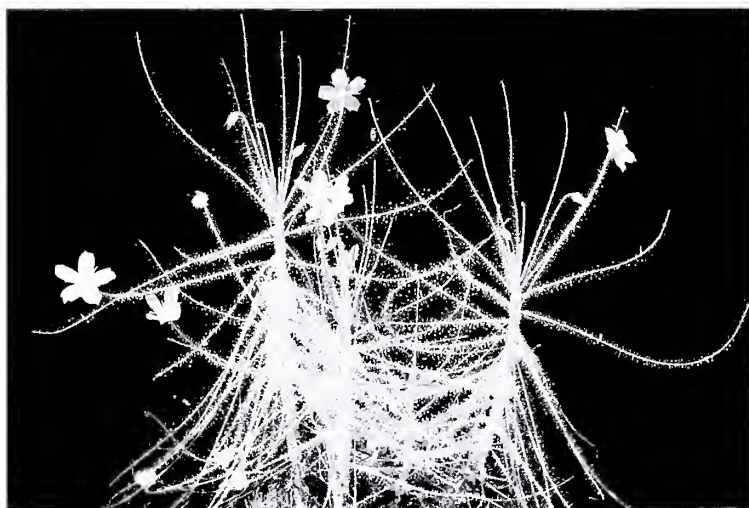
THE SAVAGE GARDEN: SEASONAL CARNIVORES FOR THE BOG GARDEN

PETER D'AMATO
California Carnivores



Keywords: cultivation: bog-garden

Many hobbyists in temperate, warm- temperate, and Mediterranean climates enjoy growing carnivorous plants outdoors year round in bog gardens and mini-bogs. Since these climates usually experience various amounts of cold weather and freezing temperatures, the plants chosen for such gardens are often cold hardy varieties that go dormant in winter. Plants selected are often American pitcher plants, Venus Flytraps, and hardy sundews and butterworts, such as *Drosera filiformis* or *Pinguicula longifolia*.



B. liniflora, by B. Meyers-Rice

One need not be limited to such a selection. There are several plants that can be grown in temperate bog gardens as annuals, or can be planted in the spring and removed in autumn before the first frosts. These plants offer unusual beauty to the bog that will last for most of the growing season.

One of my favorites as a seasonal candidate is *Byblis liniflora*, the Little Rainbow Plant. This species is a tropical annual when found in its native Northern Australia and New Guinea. While the climate is always warm, it is marked by six months of wet season and six months of dry. *Byblis liniflora* seeds germinate when the rains begin, and the plants mature rapidly, often flowering and setting seed when six to eight weeks old. They usually die off when the dry season returns and regrow from scattered seed the following year.

In cultivation, *Byblis liniflora* is often restricted to warm greenhouses and terrariums (it also is wonderful on sunny windowsills). Yet rarely does it occur to growers that the plant is well suited to any outdoor bog-garden that experiences several months of warm summer weather.

Simply scatter the poppy-like seed of *Byblis* in your garden during the spring. They thrive in the peat and sand soils most often used in bogs. As soon as the days are warm and the nights remain above 10—13°C (50—55°F), the seed will germinate and the plants will grow rapidly. Soon the glittering leaves of your rainbow plants will be continuously covered with their pretty amethyst colored flowers, putting on a spectacular show all summer long. Be sure to collect the seed as it develops, and store them dry in the fridge until the following year.

Another plant that can be grown in exactly the same manner is *Drosera burmanni*. This handsome rosetted sundew is well known for its rapidly moving tentacles, and while most forms are green, some turn a beautiful blush to crimson color in full sun and are best seen in colonies. *D. burmanni* is another tropical annual that grows throughout Australasia. When a few months old, the plants flower, set seed, and die. I have found that seed scattered in a bog will survive winter lows at least to -4°C (24°F), but it is wise to collect seed and store it over winter for the following year.

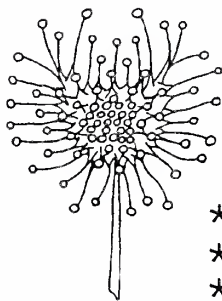
A third species I love to grow seasonally in my outdoor bog gardens is *Pinguicula lusitanica*. This tiny butterwort is native to Atlantic coastal Europe and northwestern Africa. At best it is a short-lived perennial, surviving light frost below 0°C (i.e., the low 20's °F). They grow rapidly from seed scattered in the bog and by late summer flower profusely, self-pollinating themselves. Check pods daily as they turn brown, for seed will be released quickly when the pods crack open. *Pinguicula lusitanica* is often seen as a green plant when grown in terraria, greenhouses and windowsills, but in full sun in a bog they will turn rosy pink with red veins running through their translucent leaves.

A really beautiful addition to bog gardens for the growing season are some of the Mexican butterworts, notably *Pinguicula moranensis* and its hybrids. These plants are long-lived perennials that turn into succulents during the dry but frost-free winters south of the USA border. Their compact, often clumping habits and short roots make them easy to transplant without injury. They are also quite tolerant of the peat and sand soils of bog gardens. I like to add them to my bogs when I am pretty sure no more frost will occur, which in northern California is mid-April. This usually coincides with the growth of their large, sticky summer leaves. It takes about two minutes to transplant one from its greenhouse-grown pot into the bog, using a tablespoon to lift the short roots and some soil from its container. In autumn, before the first frosts (usually November out here), I lift them out of the bogs in the same manner and return them to pots in the greenhouse. Good varieties to try are all of the *P. moranensis* types, cloned hybrids of *P. moranensis* × *ehlersiae* (*P.* × 'Sethos' and *P.* × 'Weser'), *P.* × "mola" and its hybrid cousins, plus *P. esseriana*, *P. ehlersiae* and even varieties of *P. agnata*. Aside from the startlingly beautiful flowers these plants produce in spring and late summer, the rich coloration of the foliage in sunlight will make you realize how much is missed when butterworts are grown in shaded greenhouses or under grow-lights. The abundance of insects the plants will catch also give them the energy to produce many clumps and offshoots.

Many warm-temperate and subtropical terrestrial bladderworts also are excellent seasonal additions to outdoor bogs. In spring, transfer small sections of the plants from their pots into your garden. They will rapidly spread and flower all season. In autumn, remove portions of the plants and repot these indoors for the winter. Excellent species that will add color to the savage garden are *Utricularia livida*, *U. sandersonii*, *U. dichotoma*, *U. graminifolia*, and other similar terrestrial species. Even so-called tropic-als can do well, particularly *U. reniformis*, with its large "leaves" and ravishing orchid-like flowers. Plants left in the bog over winter will certainly die off in areas of severe cold, but can be reintroduced year after year, using potted plants as rejuvenating stock.

Be imaginative with your outdoor bog or mini-bog! Just like non-carnivorous annuals that people enjoy putting in their garden for one season only, the same approach can be used for insect-eating plants.

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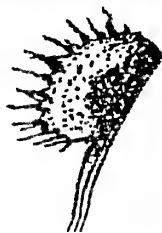


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CARNIVOROUS PLANTS NEAR MT. LESUEUR, WESTERN AUSTRALIA

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Keywords: travelogue: Western Australia (Australia), *Byblis gigantea*, *Drosera glanduligera*, pygmy *Drosera*, tuberous *Drosera*.

On the weekend of September 16 and 17, 1995, I had the pleasure in participating in a vegetation survey on a farm near Mt. Lesueur, approximately 250 km north of Perth. During this survey thirteen species of *Drosera* and the northern form of *Byblis gigantea* were found in the remnant native vegetation. These are described below.

Byblis gigantea

Byblis gigantea plants were found in two hill-slope locations. They grew in dry surfaced soil which consisted of a thin cover of fine, white, possibly wind transported quartz sand with a variable proportion of ironstone fragments derived from the underlying laterite. The plants were found on disturbed ground along fire-breaks, and would have undoubtedly have occurred in the adjacent undisturbed low kwongan¹ vegetation.

At least ten mature plants in active growth were found at each site, some of which had commenced flowering. The plants grew to 30 cm tall, had one to three stems each, and bore erect linear leaves which were up to 22 cm long. At the lower part of the stem the leaves were close together, with 1 to 3 mm internodes. The more recent growth had internodes 1 to 2 cm apart and single, axillary flowers, the latter though were not present in the lowest 2 cm of more rapid stem elongation. The pedicels were just shorter than the leaves and held a single, outfacing iridescent purple-petalled flowers ranging up to 3 cm in diameter. A single seedling with leaves 5 cm long and a poorly developed stem was found at one site.

The plants were fully bedewed and had caught a range of flying insects, including aphids, midges and a smaller number of bush flies. Most plants had at least two lime-green *Drosera* bugs on them which moved readily over the bedewed plants. No insects were seen visiting the open flowers.

These plants are part of the northern population which differs from plants around Perth. These plants are generally smaller, produce stems with less branching, and bear shorter leaves. They grow in well drained soil on hill-slopes and had petals of the same colour throughout. The southern population prefers to grow in deep sand on the edge of swamps, and the intensity of pigment in the petals is not uniform.

Drosera barbigera

Large numbers of the attractive and robust pygmy sundew *Drosera barbigera* were seen on the top and flanks of one of the laterite hills on the property. The plants grew in

¹kwongan is a term coined by Beard (1990) to describe the "heath-like" plant community which has evolved in the southwest of Western Australia, especially on the sand plains. This species-rich vegetation is rich in sclerophyllous species which have evolved in an environment characterized by frequent fires.

ironstone soil, with variable amounts of sand, often in colonies of a few tens to hundreds of plants. The semi-erect rosettes grew to 3 cm diameter, on the end of (often prostrate) stems measuring 5 cm long. Many plants were in flower, with one to two scapes each. These grew to 10 cm long and had a tight cluster of flowers with conspicuously hairy sepals. The vibrant orange-petalled flowers, to 1 cm diameter, were all open under sunny conditions, and some remained open in cloudy conditions when growing under the protection of low shrubs. The petals had a dark red base and were adjacent to the similarly coloured ovary and three threadlike styles. The anthers produced pale yellow pollen which stood out against this dark coloured zone. A brown beetle was seen visiting one flower and may act as a pollinator.

Drosera eneabba

Large colonies of the pygmy sundew, *Drosera eneabba*, grew in sandy soil on the flanks of laterite plateaus. The glistening rosettes, up to 2 cm diameter, were seen in abundance on the fire trails. The orbicular red tentacled lamina occurred at the end of straight-sided petioles and formed a flat rosette. Many plants were in flower and had one (rarely two) scapes to 15 cm tall. The sweetly scented white petals have a distinctive red dot near the ovary. These were still flowering in late October (Hislop, 1996).

Drosera erythrorhiza (subsp. *magna*?)

Scattered colonies of closely spaced rosettes of a *Drosera erythrorhiza* subspecies were seen throughout the farm in areas of deep sand, and on the edge and top of laterite plateaus. The vivid red rosettes, with up to eight leaves, were up to 8 cm in diameter, although most were smaller. The majority of plants had begun to die down although a few plants still had bedewed leaves. A few plants retained their scapes, which had already shed their seed. From the number of leaves and the size of the plants they were tentatively ascribed to subspecies *magna*, although some colonies might have been subspecies *erythrorhiza*. The closely spaced colonies of these plants indicates either that some asexual reproduction occurs or that the seed generally does not travel far from the parent plant. To determine the identity of this taxon it would have been necessary to looking at the root system and by checking the timing of flowering with respect to maturation of the rosette. Whatever its identity it is a large and beautiful plant in leaf.

Drosera gigantea subsp. *gigantea*

Scattered plants of the erect growing tuberous *Drosera gigantea* subsp. *gigantea* were seen in two locations in the area. One was in a creek bed in water to 10 cm deep, and adjacent parts of the bank where plants to 40 cm tall were seen. These were in bud with many branches, few of which had mature leaves. The second site was in deep sand several hundred metres from the nearest creek bed. Some of these plants were already in flower and many had started to go dormant. These bore the shrivelled remains of aborted inflorescences. At the second site a few plants had deep red stems.

Drosera glanduligera

Flowering rosettes of the annual *Drosera glanduligera* were found in the area. They grew on the south facing slope of a laterite plateau in sandy soil in the company of *D. marchantii* subsp. *prophylla*, and also grew in deep sand with *D. gigantea* subsp. *gigantea*. The golden green rosettes grew to 3 cm in diameter and had up to 3 scapes.

Drosera macrantha subsp. *macrantha*

Scattered plants of the climbing tuberous sundew, *Drosera macrantha* subsp. *macrantha*, were found growing on laterite plateaus and also in deep sand. At the time of the visit the species had finished flowering and was starting to die down. This species was recognised by the relatively thick (2—3 mm diameter) stem, generally golden green colour, presence of glandular hairs on the upper part of the stem, (including the inflorescence and leaf pedicels), and circular down-facing leaves borne in threes, the central one of which had a long pedicel, up to approximately 8 cm long.

Drosera marchantii subsp. *prophylla*

Scattered plants of the erect growing tuberous sundew *Drosera marchantii* subsp. *prophylla* were found growing on the flanks of laterite hills growing in sand and laterite. The plants had finished flowering, and a few had already shed their seed. The golden green plants grew approximately 25 cm tall, had conspicuously inflated bases which were covered by a numerous linear scale-like leaves, had few-flowered inflorescences with flowers held on relatively long scapes, had leaves held singly on the stem, and often grew in small groups of up to four plants. These plant groups probably derived from natural division of the tuber.

Drosera menziesii subsp. *menziesii*

A few plants of the slender climbing tuberous sundew *Drosera menziesii* subsp. *menziesii* were found near the creek, and were also found in greater abundance in deep sand near Moore River. The plants were in flower at the time of the visit and had red, slender glabrous climbing stems up to 30 cm tall. The round leaves were borne along the stem in threes, and the pedicels were generally less than 2 cm long. The deep pink-petalled flowers were fragrant and had hairy sepals.

Drosera menziesii subsp. *thysanosepala*

A large number of the slender climbing tuberous sundew *Drosera menziesii* subsp. *thysanosepala* were found growing in kwongan vegetation on the upper parts of laterite plateaus in sandy ironstone soil. The plants were very red in colour, lacked hairs (except for the sepal margins), and had leaves in threes alternating up the stem. The pale pink flowers were open (even though it was overcast), were sweet smelling and almost circular in outline. I observed a hover fly visiting one flower, perhaps feeding on pollen. It may act as a pollinator.

Drosera miniata

Abundant plants of the pygmy sundew *Drosera miniata* were found on the upper portions of the laterite plateaus. They grew in soil composed of ironstone and a variable content of sand. In sandier soils they sometimes grew with *D. eneabba*. The flat rosettes grew up to 1.5 cm in diameter, which were often hard to see. The most conspicuous feature of this species were the open flowers, to approximately 8 mm in diameter, which had iridescent orange petals with dark red, almost black veins radiating out from the center. The black ovary was surmounted by three thread-like styles. The dark red coloured stamens were not a conspicuous feature of the open flowers.

Drosera miniata often grew with *D. barbigera* and the two often flowered together. It was interesting to note that the flowers of both species were very similar in coloration and size, yet there were no signs of hybrids between these species.

A few plants of the climbing tuberous sundew *Drosera pallida* were found growing near the top of several laterite hills. This species had finished flowering and was starting to die down at the time of the visit but was identified from the other climbing sundews by the following: a glabrous stem usually 2 mm diameter; glabrous sepals; a general lime green colour to the plants; rounded, down facing lamina, borne in threes with pedicels often 2—4 cm long. Observations from June 1996 (Hislop, 1996) suggest this species may be locally common on laterite-derived soils.

Drosera stolonifera subsp. *humilis*

A few plants of the tuberous sundew *Drosera stolonifera* subsp. *humilis* were found at the farm, growing in sandy soil on the mid-slope of a laterite hill and on an adjacent property on flat ground near a creek. These many branched plants had stems to approximately 12 cm long and had no signs of the remains of inflorescences. The whorled leaves had petioles which were circular in cross section. The upper corners of the triangular lamina folded up towards each other. The slender stolon grew along the ground surface for up to 3 cm after it had emerged from above the tuber.

D. stolonifera subsp. *porrecta*

An abundance of the tuberous sundew *Drosera stolonifera* subsp. *porrecta* grew on the property on the flanks and upper portions of the laterite hills. The plants emerged vertically above the tuber and immediately formed two rosettes of short petioled leaves. The plants varied in the amount of branching which occurred above the two basal rosettes. Plants produced between one and five erect stems up to 20 cm tall. The mature leaves were borne in whorls, had furrowed petioles. Although they were triangular in outline, the upper corners were folded back so that they were almost in contact, which resulted in an almost circular appearance to the leaf blade outline. Many of the branching plants had flowered and had shed most of their seed. The inflorescences emerged from the top of the upper basal rosettes at the base of the branches. Most plants grew singly although a few had divided once.

Two other species of *Drosera* have been found on the property but were not seen during this visit. The erect tuberous sundew *Drosera microphylla* had been seen in flower on laterite hills on the property in early winter. The plants had orange petals. The pygmy sundew *D. echinoblastus*, also orange-petalled, was seen flowering in abundance in late October along the creek lines (Hislop, 1995; 1996).

The area near Mt. Lesueur has a remarkably diverse flora, as indicated by the range of carnivorous plants which were seen there. It is a botanist's delight to spend time in the area.

Acknowledgements:

I wish to thank the following: the Murdoch Branch of the Wildflower Society of Western Australia for the chance to be involved in this vegetation survey—Mike Hislop particularly, and the owners of the properties visited for granting access for the vegetation surveys .

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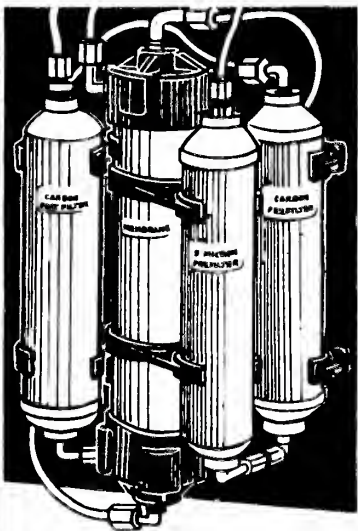
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S. flava—veined, Fitzgerald, Ben Hill Co., Georgia
S. flava—cut throat, Bulloch Co., Georgia
S. leucophylla
S. leucophylla—green with white & red tops
S. minor—Fitzgerald, Ben Hill Co., Georgia
S. oreophila—green (inquire)
S. psittacina—Fitzgerald, Ben Hill Co., Georgia
S. purpurea subsp. *purpurea*
S. purpurea subsp. *purpurea* f. *heterophylla*
S. minor & *psittacina*—Fitzgerald, Ben Hill Co., Georgia, seeds mixed
S. rubra subsp. *gulfensis*—anthocyanin-free, Santa Rosa Co., Florida
S. alata × *leucophylla*
S. flava × *leucophylla*—Milton, Santa Rosa Co., Florida
S. flava—Okefenokee Giant × *purpurea* subsp. *venosa*
S. flava × *rubra*—green with gold tops
S. leucophylla × *oreophila* selfing
S. oreophila × *flava*
S. oreophila × *purpurea* subsp. *purpurea* selfing
S. oreophila × *rubra* selfing
S. purpurea × *flava*
S. purpurea × *leucophylla*
S. psittacina × *minor*—Fitzgerald, Ben Hill Co., Georgia
Drosera affinis
D. aliciae
D. anglica—N. Slovakia
D. anglica—Czech Republic
D. anglica—Hawaii
D. binata var. *dichotoma*—small
D. binata—North Plains, New Zealand
D. brevifolia—white flower, Hampstead, North Carolina
D. burmanni
D. burmanni—Beerwah, Queensland
D. capensis—green
D. capensis—red
D. capensis—narrow leaf
D. capensis—white flower
D. capensis—purple flower
D. capillaris
D. collinsiae
D. communis
D. dielsiana
D. filiformis var. *filiformis*
D. natalensis
D. nidiformis
D. pulchella—pink flower
D. rotundifolia—Mendocino Co., California
D. rotundifolia—Czech Republic
D. spatulata—hairy sepals, Gympy, Queensland
D. spatulata—pink flower
D. sp.—Magaliesburg
D. sp.—Rhodesia
D. dielsiana × *sp.* Transvaal

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Keywords: chemistry; pigmentation.

Introduction

The red coloration found in carnivorous plants is caused by plant pigments known as anthocyanins. Because of the interest in pigment-free forms of certain carnivorous plants, Barry Meyers-Rice asked me to write a brief summary of the biochemistry of these pigments. While somewhat technical, it is a fascinating topic. If you are interested in learning more about this topic and how it is related to the biology and evolution of these plants, read on.

Biology

Anthocyanins are members of a class of nearly universal, water-soluble, terrestrial plant pigments that can be classified chemically as both flavonoid (related to flavone/isoflavone, $C_{15}H_{10}O_2$) and phenolic (related to phenol, C_6H_5OH). They are found in most land plants, with the exceptions of the cacti and the group containing the beet. They contribute colors to flowers and other plant parts ranging from shades of red through crimson and blue to purple, including yellow and color-

less. (Every color but green has been recorded). Everyone who has drunk cranberry juice is familiar with anthocyanin: it is the chemical that imparts the characteristic red color!

Anthocyanins apparently play a major role in two very different plant processes. The first is in attracting insects for the purpose of pollination. The pigments absorb strongly in the UV (ultraviolet), and to insects which see using UV wavelengths the flowers may be particularly conspicuous. These pigments play major roles in both pollination and predation in carnivorous plants, attracting insects into both the flowers and the trap apparatus. The second role anthocyanin-related pigments serve is as a protective UV screen. The pigments are produced in response to UV exposure, and protect the plant's DNA from damage by sunlight. (UV causes the paired strands of genetic material in the DNA double helix to become cross-linked, preventing cell division and other vital cellular processes like protein production).

In a related defense mechanism, anthocyanin production can be induced by ionizing radiation, which can damage DNA as readily as UV can. Chemical messengers apparently signal the damage to DNA and induce anthocyanin production in these plants.

The biosynthesis of this class of pigment is accomplished by a series of enzymes that are bound to cell membranes. Through a series of discrete chemical steps, they help convert two central biochemical building blocks (acetic acid and the amino acid phenylalanine) found in the cell's cytoplasm into the final pigment. The pigment is then excreted on the other side of the membrane into vacuoles in the epidermal cell layer. Significant genetic change in the DNA coding for the production of these enzymes results in a decrease in pigment production.

Anthocyanin pigments can be produced by growing plant cells in tissue culture. Plants showing no pigmentation in cultivation may produce anthocyanin in tissue culture (Bell & Charwood, 1980).

Environmental factors affecting anthocyanin production include light (intensity and wavelength, with blue and UV being most effective), temperature, water and carbohydrate levels, and the concentrations of the elements nitrogen, phosphorous and boron in the growth medium. Anthocyanin production can be induced by light, blue being the most effective color. Low light levels also induce the formation of different flavonoid pigments, which is another interesting adaptive response on the part of plants.

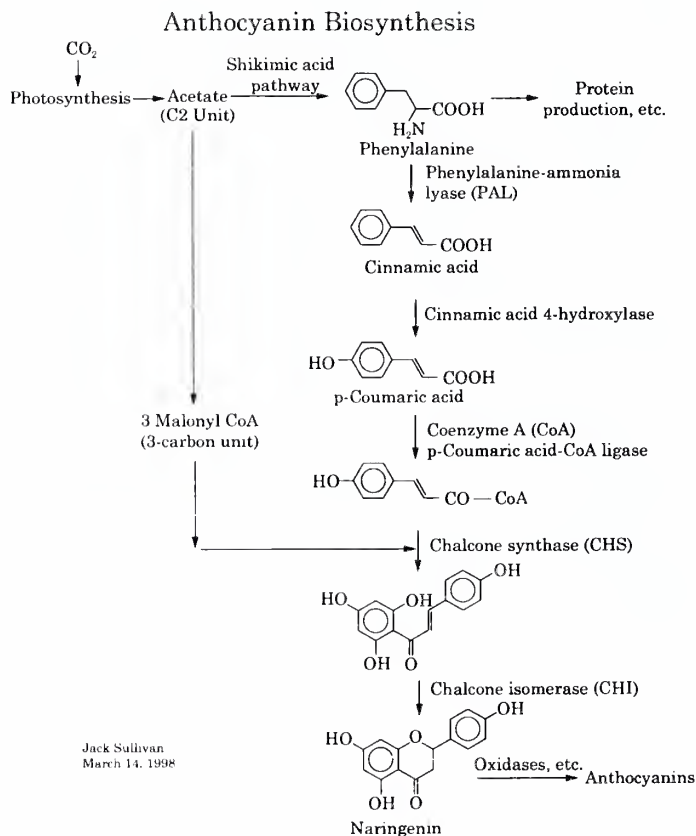
Evolution

Anthocyanin-type pigments are not found in animals, marine plants or in microorganisms. It is often theorized that anthocyanin production is an evolutionary response to plants first venturing onto the stark primordial landscape under intense UV radiation. (Significant screening of the Earth's surface from the effects of UV radiation did not occur until after the advent of terrestrial plants. Oxygen in large amounts first had to be generated by the photosynthesis of land plants before the protective ozone layer was formed).

The evolution of insect vision's response to the unique wavelengths of light presented by these plants is an interesting scenario, as is the evolution of carnivorous plants to take advantage of the insect's attraction to the sight of anthocyanin. Obviously, the plants came first and developed anthocyanin as a defense mechanism long before the first insect evolved. Carnivorous plants subsequently modified the pollination attraction mechanism to serve as an effective visual lure for their prey.

Anthocyanin pigments are assembled from two different streams of chemical raw materials in the cell: both starting from the C2 unit acetate (or acetic acid) derived from photosynthesis, one stream involves the shikimic acid pathway to produce the amino acid phenylalanine. The other stream (the acetic acid pathway) produces three molecules of malonyl-Coenzyme A, a C3 unit. These streams meet and are coupled together by the enzyme chalcone synthase (CHS), which forms an intermediate chalcone by a polyketide folding mechanism that is commonly found in plants. The chalcone is subsequently isomerized to the prototype pigment naringenin, which is subsequently oxidized by enzymes like flavonoid hydroxylase and coupled to sugar molecules to yield anthocyanins. More than five enzymes are thus required to synthesize these pigments, each working in concert. Any even minor disruption in any of the mechanism of these enzymes by either genetic or environmental factors would halt anthocyanin production.

Anthocyanin production was used as a visual marker in early studies of chemotaxonomy, which studies the relationships of organisms based on their biochemical constituents. It gave support to the one gene-one enzyme theory that is a central tenet in the field of molecular biology.



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A NOTEWORTHY FLORIDA FIND: *DROSERA FILIFORMIS* VAR. *TRACYI* (DROSERACEAE)

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1705 North Quebec Street
Arlington VA 22207-3017

Received: 22 January 1997

Keywords: field studies: pigmentation — taxonomy: *Drosera filiformis*.

General

While on a springtime expedition through the Gulf Coast during April 1994 I came upon four white-flowering specimens of *Drosera filiformis* var. *tracyi* in Franklin County, Florida. This is a rarity. The species' pink-flowering form is very abundant in that region, found commonly in roadside swales and depressions as well as in bogs and savannahs throughout. I believe this encounter with a white-flowering albino form is a first (The author is using the term albino to indicate an absence of red pigment only, not all pigmentation—ed.)

Discussion

The two forms of *D. filiformis* var. *tracyi* mentioned above seem to be identical except for their flower colors. Through close observation and analysis I have discovered several critical morphological differences that would indicate this newly discovered form is truly an albino.

The pink-flowering form is entirely green except for the color of the flower petals. However, close examinations of the tentacle heads on the leaves show that they have a distinct pale pinkish-red hue. In some plants of the pink-flowering form it is quite pale, but nonetheless it is there! I made this observation long before I discovered the white-flowering form, and have observed enough field growing specimens of the pink-flowering form to conclude that general information and literature on the species should include this finding. Clearly, when placed alongside its genetic counterpart *D. filiformis* var. *filiformis*, it has no red coloration to speak of. However pale the hue, *D. filiformis* var. *tracyi* (pink flower) cannot be designated entirely green!

In addition, older leaf stems and winter buds of the pink-flowering form of *D. filiformis* var. *tracyi* quite often exhibit a dark maroon coloration on the leaf petiole surfaces. Often said to be a sign of stress, it occurs specifically with leaves that are older and have lost their tentacles. None of the aforementioned observations of red pigmentation have been seen or observed in the white-flowering form of *D. filiformis* var. *tracyi*. Older leaves of the white-flowering form remain green until aging dries them. I have not been able to detect red pigment in any part of the white-flowering form of *D. filiformis* var. *tracyi*.

Conclusion

The likely discovery of an albino form of *D. filiformis* var. *tracyi* may support the reclassification of two distinct forms of the thread leaf sundew, that is, *D. filiformis* and *D. tracyi*.

Acknowledgements

Special thanks to Alexander Salomon who carefully reviewed the manuscript and whose input was greatly appreciated.



Figure 1: Flowers and stems of the albino *Drosera filiformis* var. *tracyi*. Note absence of any red pigment throughout.

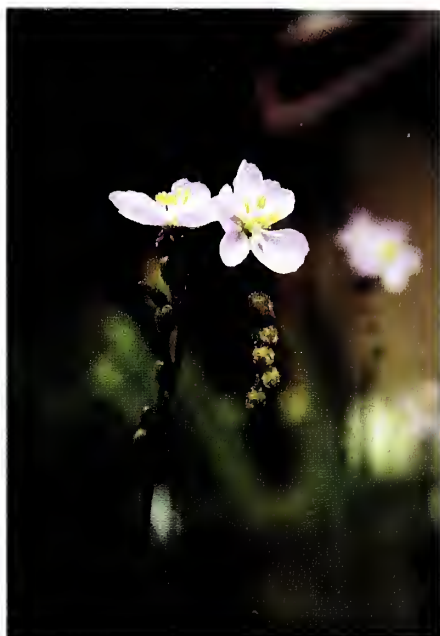


Figure 2: Flowers and stem of the pink-flower form of *Drosera filiformis* var. *tracyi*. Note the red pigment on the flower stem, raceme and flower pedicel.

References:

Clewell, A. F. 1985, Guide to the Vascular Plants of the Florida Panhandle, University Presses of Florida, Tallahassee.

OBSERVATIONS ON A SELECTION OF TASMANIAN CARNIVOROUS PLANTS

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Australia

Keywords: travelogue: *Drosera*, *Utricularia*, Tasmania (Australia).

In January 1997 I returned to Tasmania to conduct fieldwork on a selection of carnivorous plants in Tasmania. The following is an account of the more unusual observations and supplement those made during fieldwork in 1991.

The island state of Tasmania has fifteen native species of carnivorous plants: *Drosera arcturi*, *D. auriculata*, *D. binata*, *D. glanduligera*, *D. macrantha* subsp. *planchonii*, *D. peltata*, *D. pygmaea*, *D. spatulata*, *Utricularia australis*, *U. dichotoma*, *U. latriflora*, *U. monanthos*, *U. tenella*, *U. uniflora* and *U. violacea* (Erickson, 1968; Taylor, 1989). These occur throughout the state, with a general trend of winter-growing perennial and annual species growing on the eastern and northern coasts, and perennial evergreen and summer growing species growing in the central and southern parts of the island. Whilst none of the carnivorous plants in Tasmania are confined to the state there



Figure 1: Rosette of *D. spatulata* from near Southport.

Drosera pygmaea: Flowering plants of *Drosera pygmaea* were seen at two locations on the west coast of the island. The rosettes were 1 cm across and vivid red in colour. Flowers were open from approximately 9 a.m. to 1 p.m. during hot dry conditions. An interesting feature of these flowers is that the petals are bicoloured, with three red veins at the base of otherwise white-petalled flowers. Further investigation of the morphology of other parts of these



Figure 2: Flowering *Drosera binata*, with *Utricularia dichotoma* in western Tasmania, back-lit by afternoon sun.



Figure 3: Beautifully variegated flower of *Utricularia monanthos*.

are a number of local, possibly endemic variants. Unusual observations on a selection of carnivorous plant species are given below.

Drosera arcturi: The alpine sundew which grows in Tasmania is larger than the typical form in southeastern Australia and New Zealand, with leaves to 25 cm long and scapes with up to three flowers. These plants are described in Gibson (1998).

plants in Tasmania are required to see if they differ from plants in other parts of the range.

Drosera spatulata: Herbarium material indicates this species is found on the eastern and western coastal regions of the island. I have seen *D. spatulata* at two locations, one near Zeehan on the west coast and the other near Southport, on the east coast. The latter is where the type material was collected by Labillardiere. At both

locations the plants have spatulate leaves, with a wedge shaped petiole and rounded leaf apex, and retentive glands along the length of the leaves. Only white-petalled flowers were seen. The plants near Zeehan grew in dazzlingly white quartzite gravel in a shallow creek, and the plants were vividly red. Near Southport rosettes to 3 cm in diameter grew in peaty soil over a cutting in sandstone in a seepage zone (Figure 1). In both areas they grew with *D. binata*, *D. pygmaea*, *U. dichotoma* and *U. lateriflora*.

Drosera binata: The type collection of this species was made near the town of Southport by Labillardiere, and the species' description was published in 1804. Plants in this area have erect petioles, measuring up to 20 cm tall surmounted by a once (very rarely twice) forked lamina up to 8 cm across. They have erect scapes, with white-petalled flowers up to 1.2 cm in diameter. Several plants were found in clay soil beside the road which was drying out in the summer. In this environment the leaves were beginning to die but flower development continued. In wet buttongrass plains in western Tasmania, they grow well and look stunning (Figure 2).

Utricularia dichotoma: Fan-shaped dark purple flowers of *U. dichotoma* were seen in roadside gutters, creeks, and wetter areas of buttongrass sedge swamps in the south-eastern and western parts of the state. Up to seven large flowers were held on each scape, the majority of which set seed. During my visit I observed for the first time a moth feeding at a flower. The dark grey moth with iridescent dark green wings, was 8 mm long and landed on the large lower petal at an angle to the raised yellow palate ridges. It raised and lowered its head and upper abdomen with its legs as it probed the end of the nectary spur with its thin proboscis. Later observations of the inside of the spurs of this and other *Utricularia* species revealed the presence of small, colourless drops of fluid which may contain sugars.

Utricularia lateriflora: Due to its deeply rooted nature, *U. lateriflora* is a widespread species, growing from permanently wet to seasonally wet environments on the east and west coasts of Tasmania. The multiflowered scapes hold purple flowers ranging from 2 mm across to 6 mm across.

U. monanthos: The mountain bladderwort occurs in the central plateau and south-western areas and is typically purple-petalled. In one area in western Tasmania I have found a rare white-petalled form. Whilst revisiting the site in January 1997 I found variably bicoloured flowers in this population (Figure 3). These flowers were purple with irregular white spotting, and also included a startling flower which was half purple and half white. Due to the variation in colour combinations there is the chance that this is due to a virus.

In the six years between visits the quality of a few carnivorous plant sites had degraded, particularly by the introduction and proliferation of leguminous weeds. Peaty road verges which previously supported an abundance of *D. binata* and *D. pygmaea* now support few plants.

The state of Tasmania contains a range of carnivorous plant species and includes interesting variants. Further observations and simple tests are suggested to investigate these plants in more detail.

Acknowledgements:

I wish to thank Jenny and Cameron for their hospitality during my time in Hobart.

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SPECIAL REVIEW

Carow, Thomas. The World of Carnivorous Plants 1999 Wall Calendar. Verlag Carow, Holweg 15 b, 97720 Nüdlingen, Germany (see below for instructions for US customers). ISBN 3-9801839-2-0, 26 p. approximately 75 color photographs. 33 ¥ 50 cm (13 ¥ 19.5 in), \$43.70.


Reviewed by BARRY MEYERS-RICE

Thomas Carow is a skilled photographer of carnivorous plants. He demonstrates his prowess in his 1999 calendar, which is filled with stunning images of carnivorous plants, their prey, associates, and habitats.


The layout of each month is thematic. For example, March has you stalking *Nepenthes* in Borneo and Sumatra and September gives you a taste of South African *Drosera*. The photographs are flawless and carefully labeled. Carow's habitat photos are particularly nice. His photograph from the top of the tepui, Mt. Kukenam, is so wet and foggy you can feel mist on your face! Each month also has a few paragraphs of English text (which Jan Schlauer and I helped translate, although neither we nor the ICPS benefit financially from this venture). The last page includes Carow's original German text and figure captions.

Carow is able to fit all this into his calendar because it is huge. Not counting the stiff cardboard backing and the transparent protective cover, there are 26 pages of photographs. Each month is given two pages, so the open calendar is 66 ¥ 50 cm (26 ¥ 19.5 in)! Despite the work's enormity, there is not much room for the actual calendar part—if you lead even a moderately busy life you will have trouble writing in your various commitments.

This calendar's oversized layout is matched by its price. At US\$ 43.70 it is a significant purchase. But the cost is understandable since a relatively small number were printed and the calendar is so large. In the US you can buy the calendar from the folks at California Carnivores (7020 Trenton-Healdsburg Rd., Forestville, CA 95436; phone 707-838-1630), who have added \$5.70 to its original price of \$38 to cover shipping and packing (California residents must add another 7.5% sales tax). People outside the US should contact Carow directly.



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Katsu Kondo reported on an interesting Venus Flytrap: "A double flowered *Dionaea muscipula* (many petals and no stamens or gynoecium) was collected in North Carolina...on June, 1972."

E.T. Wherry, discoverer of *Sarracenia jonesii*, wrote on the two subspecies of *S. purpurea*: "For what it is worth I may note that they can be told apart in the dark: to the fingertips the pitchers of the northern plant are slippery-smooth, of the southern one rough-hairy."

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<i>Heliamphora heterodoxa</i> (divisions, 4" tall)	\$80	Venezuela	<i>Nepenthes sanguinea</i>	\$25	Genting Highlands, Malaysia
<i>Heliamphora ionasi</i>	\$80	Summit, Iltu Tepui, Venezuela	<i>Nepenthes sp</i>	\$45	Wageo Island, Iran Jaya
<i>Heliamphora minor</i> (divisions, 4" tall)	\$80	Summit, Auyani- Tepui, Venezuela	<i>Nepenthes spathulata</i>	\$55	Greenhouse
<i>Heliamphora nutans</i> (divisions, 4" tall)	\$80	Cerro Kukenan, Venezuela	<i>Nepenthes stenophylla</i>	\$45	Bano, Sarawak, Malaysia
<i>Heliamphora nutans</i>	\$38	Cerro Kukenan, Venezuela	<i>Nepenthes tentaculata</i>	\$45	Mt. Kinabalu, Sabah, Malaysia
<i>Nepenthes alata</i>	\$25	Philippines	<i>Nepenthes tentaculata</i>	\$45	G. Murud
<i>Nepenthes albo-marginata-red</i>	\$35	Malaysia	<i>Nepenthes tentaculata</i>	\$45	
<i>Nepenthes ampullana</i>	\$35	Siptang, Borneo	<i>Nepenthes thorelli</i>	\$45	Phuk Radung, E. Thailand
<i>Nepenthes bicacalata</i>	\$50		<i>Nepenthes tobaca</i>	\$55	
<i>Nepenthes bongso</i> (talangensis)	\$60	G. Talang, Indonesia	<i>Nepenthes tomonana</i>	\$50	Lampa, Gulf of Tomori, Sulawesi
<i>Nepenthes burbidgeae</i>	\$75	Kinabalu	<i>Nepenthes treubiana</i> (N. sumatran)	\$50	Sumatra
<i>Nepenthes burkei</i>	\$30	Philippines	<i>Nepenthes treubiana</i> (N. sumatran) (6" diam)	\$136	Sumatra
<i>Nepenthes carunculata</i>	\$48	G. Saigo, Sumatra, Indonesia	<i>Nepenthes truncata</i>	\$30	Philippines
<i>Nepenthes deaniana</i> ?	\$65	Palawan	<i>Nepenthes truncata</i> (14" diam)	\$175	Philippines
<i>Nepenthes edwardsiana</i> ssp. macro. (1.5")	\$87	Trus Madi, Sabah, Malaysia	<i>Nepenthes truncata</i> (15" diam)	\$90	Philippines
<i>Nepenthes eyma</i> (N. infundibuliformis)	\$45	G. Lumut, Sulawesi, Indonesia	<i>Nepenthes velutina</i> (highland)	\$60	Batu Lawi, Sarawak, Malaysia
<i>Nepenthes fusca</i>	\$40	Tambunan Road near Trus Madi	<i>Nepenthes velutina</i> (lowland)	\$60	Sungai Samba, Borneo
<i>Nepenthes gracilis</i>	\$17	Talangka Raya, Borneo	<i>Nepenthes ventricosa</i>	\$17	Philippines
<i>Nepenthes gracilima</i>	\$40	Genting Highlands, Malaysia	<i>Nepenthes vieillardii</i>	\$30	New Caledonia
<i>Nepenthes gymnamphora</i>	\$37	G. Singaang, Sumatra	<i>Nepenthes villosa</i> (1.5" diam)	\$100	Mt. Kinabalu, Sabah, Malaysia
<i>Nepenthes hirsuta</i> (rooted cuttings)	\$40		<i>Nepenthes x (bicacalata x ampullana)</i>	\$35	Siptang, Sabah, Borneo
<i>Nepenthes insignis</i>	\$59	E. Bak, Indonesia	<i>Nepenthes x (bongso x nermis)</i>	\$45	
<i>Nepenthes khasiana</i>	\$17	Assam, India	<i>Nepenthes x (bongso x maxima)</i>	\$55	
<i>Nepenthes kowi</i>	\$55	Brunei	<i>Nepenthes x (fusca x burbidgeae)</i>	\$50	
<i>Nepenthes kowi</i>	\$55	G. Mulu, Sarawak, Malaysia	<i>Nepenthes x (khasiana x truncata)</i>	\$30	
<i>Nepenthes kowi</i>	\$52	Trus Madi, Sabah, Malaysia	<i>Nepenthes x (mirabilis x khasiana)</i>	\$30	
<i>Nepenthes kowi</i>	\$75	G. Murud, 2060 meters	<i>Nepenthes x (spathulata x velutina)</i>	\$50	
<i>Nepenthes kowi</i>	\$75	M. Kinabalu	<i>Nepenthes x (truncata x maxima)</i>	\$50	
<i>Nepenthes madagascariensis</i>	\$45	Genting Highlands, Malaysia	<i>Nepenthes x (truncata x ventricosa)</i>	\$45	
<i>Nepenthes madagascariensis</i>	\$23	Madagascar	<i>Nepenthes x (velutina x kowi)</i>	\$55	
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<i>Nepenthes maxima</i>	\$37	Anggi Lakes	<i>Nepenthes x dyeriana</i> (12" diam)	\$75	
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<i>Nepenthes pervillei</i>	\$30	Seychelles	<i>Nepenthes of Borneo, C. Clarke</i>	\$65	Book, Price includes postage
<i>Nepenthes rafflesiana</i>	\$30		All plants >2" diameter unless noted		
<i>Nepenthes raphi</i>	\$35	Mt. Kinabalu, Sabah, Malaysia			

